FACULTY OF ENGINEERING AND ARCHITECTURE

DYNAMICAL SYSTEMS AND CONTROL (DYSC)

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MITIGATING RESONANCE IN MECHANICAL SYSTEMS BY SHUNTING BONDED PIEZOELECTRIC PATCHES

Abstract

Mechanical systems can be protected from resonance condition by attaching an auxilary structure, a dynamic vibration absorber (DVA) The DVA approximitaly has the same resonance frequency, allowing vibration energy to be efficiently transfered from the mechanical system to the DVA. Here, a cantilever beam was protected by a piezoelectric patch. The vibration energy is transfered to electrical energy by applying a resonant RL-shunt over the electrodes of the PE patch. In the experiment, 80 % vibration reduction was achieved.

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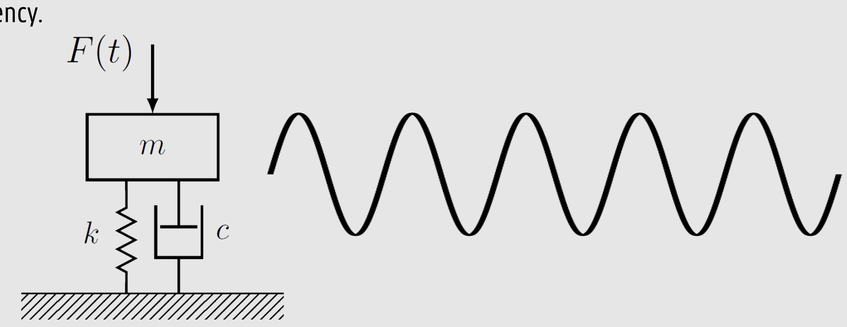
Problem: Resonance

Resonance

Mechanical systems vibrate heavily because of resonance when periodically forced with its natural frequency.

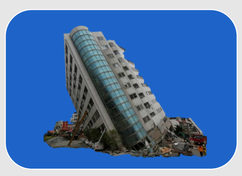


Consequence

Discomfort Operator

Failing Sensitive equipment

Mechanical Fatigue



Structure failure

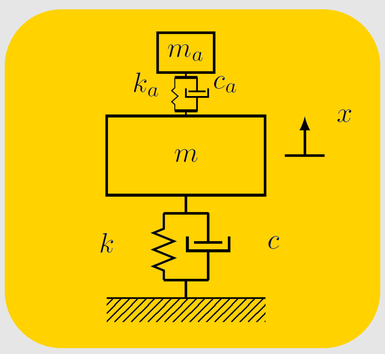
Solution: Resonance

Fight resonance with resonance

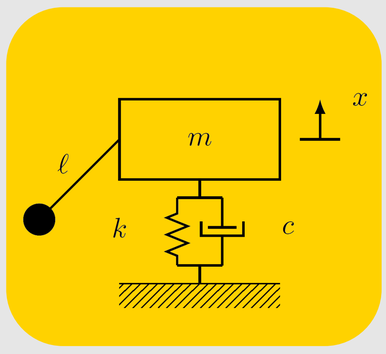
Attach auxiliary structure, dynamic vibration absorber (DVA). The DVA has a resonance frequency close to the natural frequency of the original system. This way, vibration energy is transferred from mechanical system to DVA.

Mechanical Vibration absorbers

Mass-spring-damper type



Pendulum type



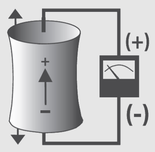
$$\omega_n = \sqrt{\frac{k}{m}} \approx \sqrt{\frac{k_a}{m_a}} = \omega_a \qquad \omega_n = \sqrt{\frac{k}{m}} \approx \sqrt{\frac{\ell}{g}} = \omega_a$$

Piezoelectric Vibration Absorber

Piezoelectric

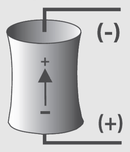
Piezoelectric material can transfer mechanical energy to electrical and vice versa

Direct effect



Straining Piezoelectric (PE) material induces Voltage

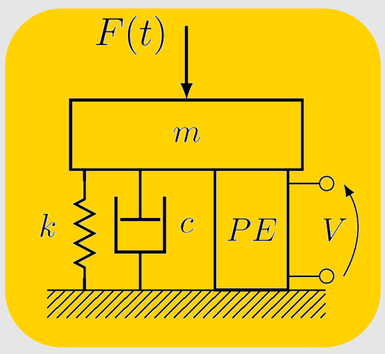
Indirect effect



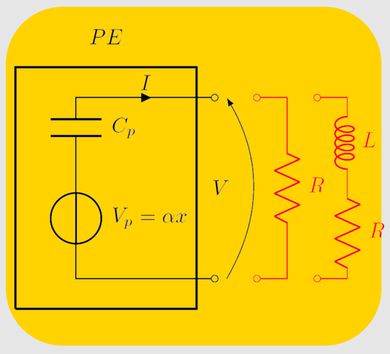
Applying voltage induces strain in PE material

Bonding Piezoelectric Patch & Mechanical system

Mechanical

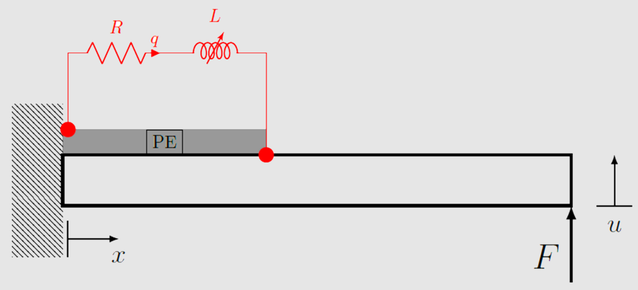


Electrical



$$\omega_n = \sqrt{\frac{k}{m}} \approx \sqrt{\frac{1}{C_p L}} = \omega_{PE}$$

Experiment

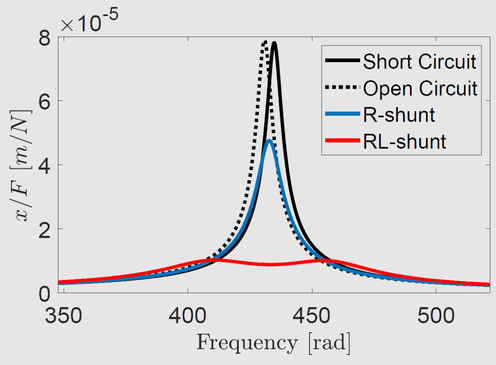


A PE patch was bonded with a cantilever beam

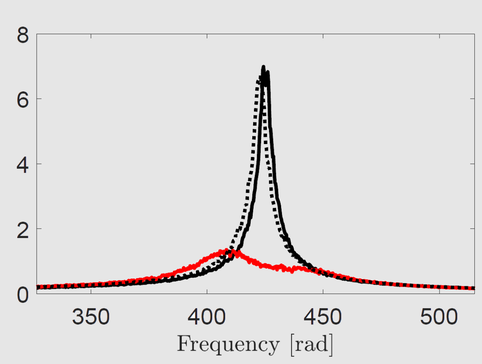
Vibrations at tip

Simulation

80 % reduction of vibration amplitude at resonance



Experimental



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